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Recent Developments in the Use of Soil Insecticides

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SOIL insects probably do some damage to every cultivated field throughout the world. Many times they mean the difference between a satisfactory crop and little or no return for the farmer's efforts. Any insect which, during its growing or feeding stages, lives either on or beneath the soil surface is a soil insect. Many of them are not harmful to crops but some rank among our most important pests.

Soil insects vary in habits. Certain species, such as white grubs (*Phyllophaga* spp.), live more or less persistently below the soil surface for long periods of time and generally feed on a wide variety of plants. Others, such as the cutworms, are non-persistent forms and may not be present in great numbers in the same field for more than one or two years. Insects of these two groups, owing to their ability to feed on numerous plants, usually occur in the fields before crops are planted.

There is still another group of soil insects, such as root and seed maggots, which tend to be restricted in their choice of host plants and which usually invade a field only after a given crop has been planted. A few species in this group, though commonly referred to as soil insects, do part or all of their damage by feeding above the ground. Corn rootworm (*Diabrotica longicornis* Say) flea beetles (*Epitrix* spp.), and sweetclover weevil (*Sitona cylindricollis* Fahr.) are examples.

The general attitude toward soil insects in the past has been "out of sight, out of mind." It is easy to overlook the damage done by underground pests, especially when the damage is light or moderate, and methods for controlling underground pests have not been too satisfactory until recently.

Research on soil insects is so new and the problems so varied that not all of the important questions can be answered yet. However, recommendations and suggestions can be made for preventing or reducing crop losses whenever soil insects are troublesome.

Control of Corn Rootworms in Iowa

In the U. S. Corn Belt corn rootworms (*Diabrotica* spp.) inflict serious damage and have been the subject of extensive studies. This work will be reported here in some detail as a helpful guide in what can be done against other soil insect pests through the proper use of soil insecticides.

Up to now aldrin has been the most widely used insecticide. It has given consistently good to excellent results when properly applied. Several other insecticides, such as heptachlor and gamma BHC, have also given excellent results in commercial use against the rootworms. These three are the leading rootworm insecticides, but dieldrin, chlordane and endrin have also given good results in test plots. DDT is not effective for most soil insects.

The method of application is important, and good results have been obtained with the following three methods:

1. Mixing the insecticide with commercial fertilizer and applying the mixture with a fertilizer attachment at the time of planting.
2. Spraying the insecticide mixture by broadcasting, either before or after plowing.

Disk the field as soon as possible after spraying to avoid insecticide losses by vaporization. BHC is recommended only for broadcast applications.

3. Using a planter-mounted power sprayer to apply the insecticide as a narrow band over the trench just behind the planter shoe; it is preferred that the seed should not be wetted in the process.

In our work to date three other methods of application after the corn (maize) is up have not proved efficient in controlling rootworms. One of these involved spray applications banded along the rows after the corn was up, with or without subsequent cultivation to work the insecticide into the soil. The second involved the use of insecticide-fertilizer mixtures as bands along the rows with a deep-placement fertilizer applicator set at a depth of 3 inches and spaced about 9 inches on both sides of the rows. The third comprised the side-dress application of insecticide-fertilizer mixtures at the time of the first cultivation.

Both powders and fine granular insecticides have been used in mixtures with fertilizers, and liquid formulations have recently been introduced for this purpose. Thorough

TABLE 1. *Recommendations for the control of some common soil insects in Iowa, 1955*

Pest	Crop	Occurrence	Control
Corn rootworm *(Diabrotica longicornis)*	Corn	Second and later years of corn in same field, or old corn fields after 1 year in another crop	Aldrin, heptachlor or gamma BHC, ½—1 lb. per acre
Black cutworm *(Agrotis ypsilon)*	Corn	Grassy lowland fields	Toxaphene 2 lb. or dieldrin ½ lb. per acre, sprayed over rows
Sod webworm *(Crambus mutabilis)*	Corn	Sod ground broken for first-year corn	As above
Maize billbug *(Calendra maidis)*	Corn	Sod ground broken for first-year corn	Toxaphene or DDT, ½ lb. per acre over rows
Seed corn beetle *(Agonoderus lecontei)*	Corn	Any field in cool wet spring	Lindane seed treatment or soil treatment
Seed corn maggot *(Hylemya cilicrura)*	Corn, soybeans	Heavily manured fields in cool wet spring	As above
White grubs *(Phyllophaga spp.)*	Corn, soybeans	Following sod	Deep early fall plowing; aldrin, heptachlor or dieldrin, 3 lb. per acre disked in
Wireworms (Elateridae)	Corn	Usually in wet or poorly drained fields	Lindane seed treatment or aldrin or heptachlor, 2 lb. per acre disked in
Sweetclover weevil *(Sitona cylindricollis)*	Sweetclover	Damaging new seedings	DDT, 1—1½ lb. or dieldrin ¼ lb. per acre
Cornfield ants	Corn	Rolling ground, usually upland	Chlordane, 1 lb. per acre sprayed over rows or soil treatments as above
Corn root aphid *(Anuraphis maidiradicis)*	Corn, wheat	Any field	Control ants to prevent damage
Grape colaspis or clover rootworm *(Colaspis flavida)*	Clover, soybeans, corn	Damage to crop following clover	As for rootworms

mixing is always needed. Emulsifiable concentrates have been used for both the broadcast and planter-mounted sprayers.

The insecticides are applied within the range of ½ to 1 pound per acre of the actual insecticide of technical grade. With aldrin and BHC, the ½ pound level has sometimes been just as effective as one pound. For the present ½ pound as the minimum and one pound as the maximum dosages are being recommended. Although it does not seem entirely logical, ½ pound banded along the row is about the equivalent to one pound applied broadcast.

It is not quite certain yet how long these treatments remain effective, but there is good evidence that one pound per acre applied broadcast and disked in gives rootworm control both the year of treatment and the following year. Lower dosages banded along the rows can hardly be expected to be effective for more than one year.

Control of Other Soil Insects

These same insecticides used for controlling corn rootworms are known to be effective against many other soil insects, but space does not permit a complete summary of the available information. Table 1 lists the more important soil insects found in Iowa, and our 1955 recommendations for their control. This should serve as a guide for anyone concerned with a soil insect problem.

Some of the other soil insects require lower dosages of insecticides than corn rootworms. For example one pound per acre of the actual insecticide of technical grade is recommended for broadcast application against rootworms; 2 pounds per acre against wireworms (Elateridae); and 3 pounds per acre against white grubs (*Phyllophaga* spp.). The effectiveness of soil treatment with a proper insecticide on the control of wireworms in cornfields is illustrated in Figure 1.

Figure 1. Effectiveness of soil treatment on the control of wireworms in an infested experimental corn field in Iowa, 1954. The middle two rows were untreated and the plots on both sides were treated with a recommended soil insecticide.

So far control measures for field crops grown on large acreages have been stressed. Frequently enquiries have been received about a general-purpose treatment for small areas such as home gardens. A common recommendation for this purpose is one pound of 10 percent chlordane dust, or its equivalent of another formulation, to each 1000 square feet. This amounts to about 4.3 pounds of actual chlordane per acre. Where food crops are grown, overdosing should be avoided. The insecticide should be applied broadcast and thoroughly worked into the soil.

Seed Treatment

Seed treatment with insecticides is being applied for controlling wireworms, seed corn maggots (*Hylemya* spp.) and seed corn beetles (*Agonoderus* spp.), all of which attack planted seeds. This method is perhaps most satisfactory for seed corn maggot and seed corn beetle control, but it is also fairly effective against wireworms, except in peat soil and in fields where there are very heavy infestations.

Seed treatment with lindane has been widely used for the past five years, and the general reaction has been favorable. A 25-percent lindane wettable powder is sold commercially for seed treatment. The manufacturer recommends a rate of 4 ½ ounces per bushel of corn. Thorough mixing is desirable and overdosing should be avoided.

Other insecticides are now entering the seed-treatment field. Dieldrin is receiving the most attention, but both heptachlor and aldrin may have possibilities. Dieldrin is now being sold for this use either alone or in combination with fungicides. Some of the producers are treating seed corn with a low level of dieldrin for the 1955 season.

Trends in the United States

The real merit of a new agricultural practice may be established only through its acceptance by growers. The use of insecticide seed treatments on corn has increased steadily in the United States since initial tests in 1949. A recent survey shows that an estimated 216,000 bushels of seed corn were treated with insecticides in Iowa in 1954. At five acres per bushel of seed, this would amount to 1,080,000 acres, or about one acre out of every ten planted.

The popularity of direct application of insecticides to the soil is even more impressive, because it involves far higher dosages and consequently much higher costs to grower. The extent to which this method has been used in the three important corn-growing states, Iowa, Nebraska and Illinois, is represented in Table 2. The application of soil insecticides in Iowa increased from zero in 1950 to an estimated one acre of corn out of every 17 acres planted in 1954.

TABLE 2. *Estimated corn acreages treated with soil insecticides in Iowa, Nebraska and Illinois, 1951-1954* [a]

State	Year	Number of acres treated with insecticide–fertilizer mixtures	Number of acres treated with other methods [b]	Total
Iowa	1951 [c]	10	15	25
	1952	15,000	10,000	25,000
	1953	200,000	125,000	325,000
	1954	362,500	237,500	600,000
Nebraska	1954	220,000	1,520,000	1,740,000
Illinois	1954	12,500	112,500	125,000

[a] Iowa estimates for 1952 to 1954 are based on surveys conducted by Dr. Harold Gunderson. The 1954 estimates for Nebraska and Illinois were obtained by personal communications with entomologists Roscoe Hill and Robert Roselle of Nebraska and John Bigger of Illinois.

[b] Mostly sprayed, either broadcast or banded on the rows with planter-mounted sprayers. This figure does not include the acreage planted with insecticide–treated seed.

[c] The 1951 acreage consisted only of Iowa State College experimental fields.

The data cited here are primarily from the Corn Belt of the United States, because our experience has been in this area. However, the same materials have been widely used in other areas for the control of many pests on a wide variety of crops. Table 3, adapted from a table published by Jacob [1], summarizes the recommendations or approvals of various states for the use of insecticides in mixture with fertilizers for the control of soil insects.

TABLE 3. *Summary of state recommendations or approvals for including insecticides in fertilizer for soil insect control in the United States*

Insecticide [a]	Dosage in pounds per acre	Number of pests involved	Number of crops involved
Aldrin	½ – 6	17	27
Chlordane	½ – 10	15	23
DDT	1 – 25	8	8
Dieldrin	½ – 6	15	13
Heptachlor	½ – 6	17	27

[a] Two states approve toxaphene-fertilizer mixtures, and one state approves BHC or lindane in fertilizers for use on lawns and golf courses only.

Cultural Control

The question often arises whether soil insects can be controlled by cultural practices. To the extent that a cultural control method constitutes also a good general practice, it should be followed. Unfortunately it just does not work for many soil insects. For example, where meadow is included in the rotation in the Corn Belt, it is logical to follow it with corn. Yet in sod or heavily manured land, cutworms, wireworms, white grubs, webworms, billbugs and seed maggots are most likely to give trouble.

Rotation for controlling corn rootworms is an interesting special case. Our common or northern corn rootworm, in its larval stage is supposed to feed only on corn, and the eggs are laid in cornfields in the fall. Theoretically, crop rotation should control it, but often it does not work out this way in actual practice.

Heavy damage is often observed in old cornfields planted either to oats or soybeans the previous year. Two years with no corn always breaks the cycle and gives control. But this sort of rotation is not considered desirable by some farmers.

In summary, one should use the best farming practices known, including those for insect control where they seem justified. The stage has been reached where soil insect control is not just extra expense, but a definite part of good farming when control is needed.

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[1] Jacob, K. D. Status and problems of fertilizer-pesticide mixtures. Jour. Agr. & Food Chem. 2 : 970-976. 1954.

Cotton Spraying in the Sudan Gezira

I. Yield Increase from Spraying and Spraying Methods

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THE Gezira Scheme is an irrigated area situated along the west bank of the Blue Nile and watered by gravity from the Sennar Dam. Approximately 235,000 feddans[1] of long staple cotton (*Gossypium barbadense*) are grown annually in the area by a single administration known as the Sudan Gezira Board. Tenant farmers, who are joint partners in the Scheme, normally each cultivate 10 feddans of cotton and the whole of the area is typically divided into 90-feddan cotton "numbers" consisting of 9 such holdings or tenancies. Yields from each holding, together with other data, have been maintained since the beginning of the Scheme and the records available are probably unparalleled at least in tropical agriculture. The relatively uniform soil conditions, layout and regularity of the cotton fields and the big area of crop under a single management make the Sudan Gezira uniquely suited for large-scale application of and experiments in the chemical control of insect pests.

The development of commercial spraying of cotton in the Sudan Gezira to control the cotton jassid (*Empoasca lybica* Berg.) has been described by Cowland and Edwards (1) and Snow and Taylor (4). The purpose of the present paper is to examine the benefits to the area which have resulted from spraying, and to describe recent developments in the practice of spraying. The entomological problems which have arisen as a result of spraying will be discussed in a later paper.

Yield Increases from Spraying

Data for calculating the value of the commercial application of a particular control measure are seldom available in a form suitable for critical analysis. Snow and Taylor (4) were able to utilize the carefully compiled records of the Gezira Scheme to make a statistical analysis of the yields from sprayed and unsprayed fields. Their conclusions may be regarded as highly reliable within the limitations they mention because, during the years covered by their analysis, there were still large areas unsprayed with which the yields from sprayed areas could be compared. So convincing was the evidence of benefits which could be attributed to spraying that the proportion of sprayed to unsprayed cotton has become progressively bigger, until, during the last three years, only about 5 percent of the cotton of the Scheme has remained unsprayed. It is estimated that, of all the cotton grown in the Blue Nile Province during the season 1953/54 and irrigated from the Blue and White Niles, about 300,000 feddans were sprayed with DDT and only about 10,000 were unsprayed. Usually the unsprayed cotton does not receive treatment because it is late sown or in poor condition for some other extraneous reason at the time of spraying. It is therefore, under present circumstances, clearly undesirable for the yields from such inferior cotton to be compared with those of the bulk of the area to indicate the benefits of spraying. The cotton of the Gezira Scheme is, however, divided into 44 administrative areas, known as Blocks, and it has been the practice to carry out an unreplicated experiment in each Block in which standard sprayed and unsprayed treatments are applied to a single 90-feddan number. This experiment is now repeated in each Block and it may be regarded as one in which the sprayed and unsprayed treatments are replicated at random throughout the sprayed areas of the Gezira. The results from these experiments are summarized

[1] One feddan = 0.42 hectare = 1.038 acres.

in Table 1. From the results of these experiments it is possible to postulate that during the 9 years of spraying the Gezira Board has cropped over 900,000 kantars of seed cotton more than it would have done in the absence of spraying. The validity of such a postulate is open to serious uncertainty. It is true that the increases in yield obtained in the experiments do not differ radically from those demonstrated by Snow and Taylor (4) in their analysis of bulk yields from sprayed and unsprayed areas. Nevertheless since 1950 the proportion of sprayed cotton has increased so greatly that the insect regime associated with unsprayed cotton may have been so affected by the wide-scale application of insecticide on surrounding cotton, that the yield from a single unsprayed cotton number may bear a very different relationship to that of a sprayed number than in the past. So many complex factors of population dynamics are involved here, that the effect of such a change in the environment cannot be deduced with our present knowledge. Observations, however, suggest that by 15 October, which is the mean spraying date in the Gezira, colonization of cotton by insects is more or less complete and movement from one field to another is limited. Population movements therefore may be of less importance in complicating interpretation of the experimental results than they appear to be at first. A more serious objection is that the cotton numbers in the experiments are not strictly selected at random but with a deliberate bias to obtain pairs of comparable fertility. This objection renders a statistical analysis of the data of dubious value, or at least applicable only to the type of land selected.

With these limitations in mind, and in the absence of more reliable data the standard errors of the experiments conducted between 1948/49 and 1953/54 have been calculated. In 4 out of the 6 years covered by the calculation the increase in yield from spraying has been significant at 5 percent level.

It is postulated that the benefit to the Gezira from spraying since 1945 is of the order of 225,000 bales (400 lb. each) of ginned cotton. While it is not possible to prove or disprove the accuracy of the figure, it may be regarded as an approximation useful in formulating a spraying policy in the Gezira.

TABLE 1. *Estimated increase of cotton yields following DDT spraying in the Sudan Gezira, based upon experiments carried out in single 90-feddan cotton numbers in various administrative Blocks*

Crop season	Number experiments	Yield increase in kantars per feddan [b]	Standard error, kantars per feddan	Total area sprayed, in feddans	Estimated total yield increase, in kantars
1945/46	[a]	0.69	—	1,450	1,000
1946/47	[a]	1.40	—	8,346	11,684
1947/48	[a]	1.00	—	34,452	34,452
1948/49	11	0.71	0.52	77,850	55,273
1949/50	15	1.57	0.40	122,660	192,576
1950/51	27	0.50	0.27	162,990	81,495
1951/52	23	1.03	0.30	205,010	211,160
1952/53	39	0.76	0.24	230,168	174,928
1953/54	38	0.66	0.24	229,575	151,519

[a] During the first three seasons estimated yield increases were obtained from comparison of total yields in sprayed and unsprayed areas of Blocks in which spraying was carried out.

[b] One kantar = 315 rotls or 312 lb. seed cotton yielding approximately 100 lb. lint of Domains Sakel cotton or 107 lb. lint of X 173OA.

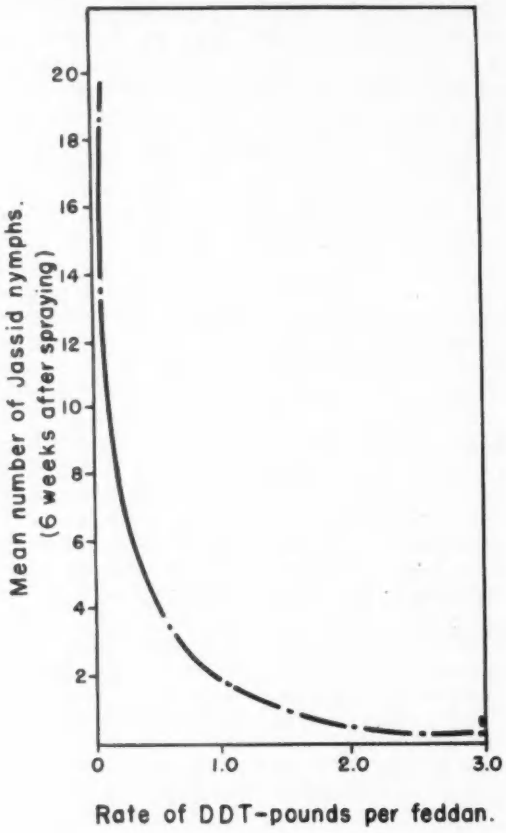

Figure 1. Relation of cotton jassid infestation to rate of DDT application.

Development of Spraying Methods

Snow and Taylor (4) demonstrated variation in yield increases with the date of spraying. In 4 out of the 5 years investigated yield was a linear function of the date of spraying, i. e. the earlier the spraying, the greater the response. This was to be expected from the earlier work by Crowther (2) on the physiology of the cotton plant in the Gezira. Since then, in several experiments, the writer and others have demonstrated that destruction of late infestation by jassids can be accompanied by a decrease in yield, in comparison with results obtained from control of early infestation. Investigation of spraying methods has therefore followed two major, but complementary lines of approach:

(*a*) to reduce the cost of spraying; and
(*b*) to increase the speed of spraying, so that the bulk of the cotton can be sprayed near to the optimum date.

The progress made in this investigation is discussed in the following paragraphs.

Choice of insecticide and dosage rate. A large number of laboratory and plot experiments have been carried out with a wide range of chemicals to find the insecticide best suited for jassid control in the Gezira. The residual deposit of a film of DDT applied to cotton leaves as a 0.1 percent drenching spray (equivalent to 1.0 lb. technical DDT

per feddan) was shown by D. Pollard to remain toxic to the cotton jassid for at least 30 days in the Gezira. This long residual effect has been considered necessary to enable jassid control to be achieved by a single spray. No other insecticide was found to have a comparable residual effect, a conclusion which was supported by plot experiments in which increases in yield from DDT spraying were usually greater than those obtained with other insecticides. Similar experiments demonstrated that emulsions were generally superior to wettable powders, while pastes were usually as good as emulsion but were more difficult to apply commercially. For several years, therefore, DDT as emulsions or emulsifiable concentrates has been virtually the sole insecticide used in large-scale spraying in the Gezira.

Laboratory work by Cowland and Edwards (1) in 1945 had shown that an emulsion containing 0.05 percent DDT was not sensibly less effective in controlling jassids than one containing 0.1 percent DDT, both being applied to run off. These rates were regarded respectively as equivalent to 0.5 and 1.0 lb. technical DDT in 100 gal. spray per feddan. A standard dosage rate of 1.0 lb. DDT per feddan was chosen for commercial application. Experiments on a large scale during the season 1949–50 and 1950–51 on the jassid control and yield increase from smaller dosages gave results which were consistently inferior to the standard dosage, although not significantly so (4). Recent experience, however, has shown that application of a spray with better atomization in a smaller quantity of water avoids the loss of insecticide by run-off and the possibility of using smaller doses of DDT has been re-examined. The writer and R. Amsden have shown that a relationship can be deduced between dosage and persistency in jassid control. This is shown in Figure 1 where the mean number of jassid nymphs recorded in a series of counts taken during 6 weeks following spraying are plotted against the dose of DDT recovered from glass slides placed within a crop to which a varying rate of DDT spray had been applied by aircraft. The curve shows clearly that a critical point is reached at about 0.5 lb. DDT per feddan, further dosage reduction leading to a steep rise in the post-spray number of jassids. Nevertheless all post-spray populations were extremely low, and indeed too low to be reflected in yield differences under the experimental conditions adopted during that season. The results therefore encourage the belief that considerable reduction in dosage rate may accompany improved methods of application. This belief finds support in the results obtained in large–scale application by aircraft of 0.5, 0.75 and 1.0 lb. DDT per feddan as summarized in Table 2.

TABLE 2. *Cotton jassid control by different dosage rates of DDT, based upon results of several experiments*

Rate of DDT spraying, in lb. per feddan	Average number jassid nymphs per 100 leaves recorded 6 weeks after spraying
0.50	2.1
0.75	4.0
1.00	0.9

Experiments are continuing and a continuous program of reduction of the commercial dosage rates of DDT in the Gezira can be anticipated.

Reduction in volume rate of application. In the early years of spraying DDT was applied at a rate of 1.0 lb. technical material in 100 gal. of water by means of a tractor–drawn inter-row crop sprayer having a boom fitted with droplegs to secure a good coverage of both surfaces of all leaves of the cotton plant (1). Since the crop is irrigated at 10- to 14-day intervals the number of spraying days is limited, particularly with heavy equipment. Experiments carried out between 1949 and 1954 by the writer, Pollard, Toms and others showed that the volume rate of application of spray could be reduced from 100 gal. to 10 gal. of spray per feddan without loss of efficiency in jassid control and commercial application of this principle has enabled the tractor output per day to be trebled. Further reduction in volume rate of spray is also possible and large-scale experiments conducted during the 1953/54 season resulted in mean post-spray infestations of 1.0, 0.6 and 0.3 jassid nymphs

per 100 leaves during 4 weeks after applying 1.0 lb. DDT at 10, 5 and 2.5 gal. of spray per feddan respectively. It is likely, however, that little, if any, economic advantage is to be obtained from a reduction of volume rate below 5 gal. of spray per feddan with conventional equipment, by which coverage of 300 feddans in a 24-hour day can be achieved in practice with one tractor. This achieved output is only 56 percent of the theoretical maximum output for such an operation, and the loss in efficiency which it represents can be attributed in part to nozzle blockages resulting from the use of canal water for dilution of the insecticide. Canal water has a high content of suspended matter and it would be preferable to avoid its use altogether.

The insecticide concentrates in general use in the Sudan contain 25 percent DDT. If this concetrate is to be applied undiluted a volume rate of application of 0.4 gal. of spray per feddan must be achieved. No conventional inter-row crop sprayer can produce such a low output, but a prototype machine has been designed for the Sudan Government by R. J. Courshee of the National Institute of Agricultural Engineering in England. This machine will be tested next year at volume rates ranging from 0.1 to 1.0 gal. per feddan, at which rates a coverage of 600 feddans per 24-hour day per tractor could be expected, provided such a large area of dry crop can be kept available in one vicinity throughout the spraying period.

Aerial spraying. Both fixed and rotary wing aircraft have been used extensively in the Gezira for the past 4 years. Both types have many advantages over ground machines, having a higher daily output and operationally being independent of the watering of the crops. Detailed comparisons of the control of jassids achieved by aircraft and ground machines, the latter at high and low-volume rates, were made by the writer and Pollard during the season 1951/52. It was found that although the kill obtained when the insecticide was applied by a fixed-wing aircraft was slower during the first 24 hours, little difference could be detected in the control achieved during the four weeks following spraying from any of the methods of application compared. Furthermore the kill of nymphs on the lower leaves was as good when DDT was applied by aircraft as when applied by land machine. When cuprous oxide was incorporated in the spray the amounts recovered did not differ appreciably between one method and another. These results are summarized in Table 3, where the DDT equivalent is shown in place of the copper which had been estimated chemically. Following this work fixed-wing Auster aircraft, which operationally were considerably cheaper than helicopters, became firmly established in the Gezira spraying operation but it was soon apparent that efficiency could be considerably improved. The standard technique which had been adopted was to apply 1.0 lb. DDT in 3 gal. of spray per feddan over a swathe of 20 meters. This swathe was selected because it appeared to be more or less the characteristic swathe of the aircraft and equipment used when a spray was applied in still air, and it furthermore coincided with the width of the strips into which a cotton number of 90 feddans is laid out for irrigation purposes. Thus the pilot could fly down the length of a cotton number (distance 1350 m.) and apply the spray to a standard 20 m. strip without the need of ground markers. Fourteen or sixteen of such runs would complete the spraying of a cotton number. Spraying at a rate of 3 gal. per feddan would require 7 sorties each of 2 minutes duration. Allowing for return to the landing ground, refilling etc. the total time required to spray a 90–feddan number was about 60 minutes. If an undiluted 25 percent concentrate were applied at 0.4 gal. of spray per feddan, a whole cotton number could be sprayed in a single sortie, occupying 14 minutes. Furthermore, if the swathe could be increased from 20 to 40, 70 or 140 m. (an eighth or a quarter or a half of the width of the cotton number) the duration of a single sortie could be reduced to 7, 3.5 and 2 minutes respectively.

An investigation of this approach was therefore begun in 1951 and the results achieved so far will now be briefly described.

Early work by the writer showed that the cotton plant was extremely tolerant of high dosages of 25 percent DDT concentrates. Nevertheless some leaf scorching was apparent and sometimes serious. More detailed investigations by R. Amsden led to the

TABLE 3. *Calculated distribution of DDT on cotton plants, as estimated from recovery of cuprous oxide sprayed with DDT, at the rate of 1.0 lb. per feddan*

Method of application	Amount of DDT in mg. per 100 sq. cm. of leaf surface [a]		
	Top leaves	Middle leaves	Bottom leaves
Inter-row crop sprayer			
33 gal. per feddan, with down-pipes	0.07	0.26	0.15
33 gal. per feddan, without down-pipes	0.07	0.21	0.10
10 gal. per feddan, without down-pipes	0.15	0.20	0.10
Auster aircraft			
3 gal. per feddan	0.06	0.19	0.10

[a] Top leaves – from 5 uppermost nodes; middle leaves – from 5 middle nodes; bottom leaves – from 5 remaining nodes.

conclusion that droplet size rather than dosage was involved and it was shown that while droplets of 200 μ and above of a 25 percent concentrate produce visible burning of the leaf, droplets below this size even of a 40 percent concentrate, had no harmful effect.

In 1953 a randomized replicated experiment was carried out by I. Darter, J. Robson and L. Hewitt in which the effect on jassids, thrips, whitefly and yield of spraying 1.0 lb. DDT by Auster aircraft at 2, 1 and 0.4 gal. of spray per feddan were compared. This involved spraying 5, 10 and 25 percent concentrates of DDT. The results were encouraging and the mean jassid numbers recorded per 100 leaves during the 5 weeks following spraying were 1.2, 7.4 and 7.3 for 3, 1 and 0.4 gal. of spray per feddan respectively, against 67.3 for unsprayed plants. There was no significant difference between the yields of sprayed treatments.

A more detailed experiment was carried out by R. Amsden and the writer in which a 25 percent concentrate of DDT was applied by an Auster aircraft at 0.4 gal. of spray per feddan over swathes of 20, 40, 70 and 140 m. using the drift technique developed for locust control and described mathematically by Sawyer (3). The mean jassid numbers per 100 leaves recorded during the 6 weeks after spraying were 2.3, 4.8, 3.7, 22.1 and 213.8 for the 20, 40, 70 and 140 m. swathes and unsprayed treatment respectively. There was no significant difference between the yields of the sprayed treatments. An analysis of the drop spectrum used in this experiment and of the recovery of the DDT across the swathe indicated ways in which a more even distribution of spray and a better recovery of DDT on the cotton plant could be achieved.

During the present season work along these lines has continued and results to date give strong reason to believe that a very high degree of jassid control can be achieved by spraying a 40 percent concentrate in droplets of not more than 200 μ in diameter at a rate of 0.25 gal. per feddan. Furthermore it seems likely that not only will it be possible to use an increased swathe, but actually a better leaf coverage and jassid control may be achieved by applying the spray over a 40 or 70 m. than over a 20 m. swathe. There appear to be sound theoretical reasons for this expectation.

Should this new technique of spraying be applicable on a commercial scale it would be possible to increase the daily spraying out-

put ten-fold, with a considerable saving in spraying costs.

Summary

A review is made of the benefits which have been enjoyed in the Gezira, the main cotton producing area of the Sudan, as a result of spraying. This practice began in 1945 when 1,450 feddans of cotton were sprayed with DDT against the cotton jassid. In the season 1953/54 over 230,000 feddans were sprayed. The increase in cotton production between the years 1945-1954 which can be attributed to spraying is estimated at over 900,000 kantars of seed cotton or about 225,000 standard 400 lb. bales of cotton lint.

Methods of spraying are described and emphasis is placed on the need for a very high daily output to enable large areas to be sprayed near to the optimum date. This has been achieved by reduction in volume rate of application of spray and it has been shown that a high degree of jassid control can be achieved when a 40 percent concentrate of DDT in solvent is sprayed by aircraft at 0.25 gal. of spray per feddan over swathes of 20, 40 and 70 metres. Similar reduction of volume rates is planned for ground inter-row crop sprays. This reduction in volume rate has resulted in considerable economies in costs of spraying. Further economies are expected from reduction in dosage rate of DDT as more efficient methods of application are practised.

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Outbreaks and New Records

Israel

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The following notes cover the incidence of major plant pests and diseases during the period from May to the end of December 1954. A number of insect pests were unusually abundant, whereas many others, such as the Mediterranean fruit fly (*Ceratitis capitata*), codling moth (*Carpocapsa pomonella*), grape berry moth (*Polychrosis viteana*), durra stem borer (*Sesamia cretica*), pomegranate blue moth (*Virachola livia*), Chrysomelid beetles, aphids, thrips and red mites, some of which are not included in the present notes, occurred only in normal populations.

Fruit Trees

Citrus. The warm weather in autumn and early winter with prevailing high day temperatures increased the population of citrus pests, mainly the citrus black scale (*Chrysomphalus aonidum* L.), the Florida wax scale (*Ceroplastes floridensis* Comst.), and the citrus rust mite (*Phyllocoptruta oleivora* Ashm.). Control measures against the black scale were carried out in orange groves from July until late in the season, in some cases with two treatments. Approximately 80,000 dunams (1 dunam = 0.1 hectare) were sprayed with mineral oils. The citrus rust mite was active in plantations on the coastal plain from June to December and later. Single sulfur treatment did not always prove effective and additional treatments were often required.

Field experiments on the control of the Mediterranean fruit fly with dieldrin and Diazinone incorporated in oil and dusting with 50 percent methoxychlor wettable powder applied from airplanes, were carried out in different localities, on a total area of 1,000 dunams.

Deciduous fruits. Root rot of apple trees caused by *Sclerotium rolfsii* Sacc., which was prevalent mainly in the coastal plain, has extended to the northern part of the country. Although certain apple stock varieties were observed to show some resistance and the disease is being partially controlled by cultural practices, such as the increased use of organic matter for manuring and proper irrigation, it still presents a serious menace to the main apple-growing areas due to the increased cultivation of sugar beets and peanuts which are very susceptible to this disease.

Bitter rot of apple (*Glomerella cingulata* Spauld. & Schrenk) was found in a limited area where spraying with Phygon and zineb has reduced the damage to a minimum. Control of apple powdery mildew (*Podosphaera leucotricha* Salm.), on the other hand, was found to be diffcult under high temperatures prevailing in the summer when sulfur sprays cause leaf and fruit burning.

Plum rust disease (*Tranzschelia pruni-spinosae* Diet.) appeared early in the season and attacked mainly Santa Rosa plums; 15 percent zineb sprays gave satisfactory control.

Brown rot (*Sclerotinia laxa* Aderh. & Ruhl.) was observed for the first time in one locality in the hilly region of Judea, causing wilt of blossoms and young twigs of Wickson plums and apricots.

Considerable build-up of the population of olive scale (*Parlatoria oleae* Colvée) on Santa Rosa and Kelsey plums has been recorded in the northern part of Israel. Heavy attacks may occur in the next season.

Sulfur treatments against red spider (*Tetranychus urticae* Koch.) on fruit trees proved in some cases unsatisfactory. Results of control with Aramite were successful on deciduous fruits, but not always on vegetables.

Other fruits. The tropical fig borer (*Batocera rufomaculata* De Geer) has since 1952 considerably extended its distribution. In the north it reached the Lebanon border, in the south the vicinity of Tel-Aviv and Lydda and also extended into the eastern part of the Plain of Esdraelon, up to the eastern borders of the country. The problem is becoming of more than national concern, and it is feared that this pest may reach, in the course of the years, the fig-growing districts of Turkey. Experiments are now under way to combat the adults with insecticidal sprays.

On carob bean (*Ceratonia siliqua*) leaf spot disease caused by *Cercospora* sp. inflicted considerable losses during the fruiting period.

Vegetables and Field Crops

Pests causing losses of vegetables and field crops during the summer were mainly the naked caterpillars of Noctuids, such as *Prodenia litura* F., *Heliothis* spp. and *Leucania* spp., which are all extremely polyphagous, onion thrips (*Thrips tabaci* Lind.), leafhopper (*Empoasca lybica* Berg.), and whitefly (*Bemisia tabaci* Genn.). Control measures using DDT against the last two insects failed in most cases.

Populations of *Mesomorphus* sp., a Tenebrionid beetle, increased during the last two years, causing more and more damage to vegetable seedlings, summer field crops and dried leguminous hay. Field experiments on efficient control measures are being planned.

Diseases, on the whole, caused little damage. Although sporadic outbreaks of potato blight (*Phytophthora infestans* de Bary) occurred in both tomato and potato crops, loss in yields was relatively small. A heavy outbreak of brown rot (*Pseudomonas solanacearum* E. F. Sm.), however, caused considerable losses in seed potato production.

On field crops, net bloch (*Pyrenophora teres* Drechs.) and stripe (*Helminthosporium gramineum* Rabh.) caused heavy losses to barley, especially the variety B. M. C. Climatic conditions were especially favorable for the development of these diseases.

Cotton. Cotton was grown for the first time in Israel on a commercial scale, the area being approximately 3,000 dunams. The crop was entirely irrigated, mainly under overhead irrigation. The most important pest was spiny bollworm (*Earias insulana* Boisd.) against which frequent applications of endrin as a low volume spray about every fortnight were successful. These treatments, incidentally, controlled also onion thrips, cotton aphid, whitefly, leafhoppers and caterpillars of the Noctuids such as *Prodenia litura* and *Heliothis* sp. A decline in the attack of spiny bollworm was noticed during the hottest months, July and August, in the interior valleys (Beisan and Jordan) but not in the coastal region.

Pink bollworm (*Platyedra gossypiella* Saund.) increased in number late in autumn after the spraying was discontinued; it seemed to occur more frequently in the neighborhood of areas where cotton was grown experimentally the previous season. Red mite (*Tetranychus urticae*) did not cause serious damage in 1954.

Plant Quarantine Announcements

Federal Republic of Germany

An Ordinance of 4 March 1955 for prevention of the introduction of Mediterranean fruit fly establishes measures regulating the importation of fresh fruit into the Federale Republic of Germany and Berlin.

The importation of fresh fruit infested or suspected of being infested by the Mediterranean fruit fly (*Ceratitis capitata*) is prohibited. Consignments of fresh citrus fruits, apricots and peaches must be accompanied by an official phytosanitary certificate in German and in the language of the country of origin, issued within ten days prior to the date of shipment, stating that the consignment has been found, upon inspection, to be free from infestation. This restriction does not apply to fruit in travellers' baggage, or in gift parcels of not more than 5 kg. for use of the consignee.

At the point of entry, the consignments of fresh citrus fruits, apricots and peaches, as well as their packings and means of transport, will be inspected. Other fruit, personal baggage and gift parcels will be inspected only when there is reason to believe that they are infested.

The certification and inspection mentioned above are not required for consignments in transit under customs control.

United Kingdom (England and Wales)

The Importation of Potatoes and Vegetables Order, 1955, which will come into operation on 27 February 1955, sets forth the modified conditions under which new potatoes and certain vegetables from specified countries and districts in continental Europe may be imported during specified periods in 1955. On the expiry of the specified periods, the full requirements of the Importation of Plants Order, 1955, will apply.

New potatoes. New potatoes grown in the countries specified hereunder may be imported in 1955 during the indicated periods, subject to the conditions specified.

	Period of Importation
France	27 February – 31 May
Portugal	27 February – 15 May
Spain	27 February – 8 May

Consignments of such new potatoes must be accompanied by an official certificate in conformity with the model certificate provided in the International Plant Protection Convention (First Schedule to the Order) and the examination referred to in the certificate must be carried out immediately prior to the date of dispatch. They must also fulfill the following requirements:

(*a*) They must have been grown at a distance of at least 2 km. from any place where the wart disease (*Synchytrium endobioticum*) or ring rot (*Corynebacterium sepedonicum*) has occurred at any time;
(*b*) They must have been grown in a district where an intensive system of control of Colorado beetle (*Leptinotarsa decemlineata*) is in operation;
(*c*) They must have been riddled and thoroughly washed and be free from soil and Colorado beetle infestation.

Vegetables. Raw vegetables mentioned below grown in the countries and districts specified may be imported in 1955 during the indicated periods, subject to the conditions specified.

From Belgium (Districts of Louvain and Malines), France (Districts of Barfleur, Caen, Creances, Launion, Nantes, Perros-Guirec, Rennes and Saint Pol de Leon), and the Netherlands (all districts):

Cauliflowers, summer and winter varieties (trimmed); 1 April – 15 May
Carrots, with foliage not exceeding 5 in.; 1 April – 15 October

From the Netherlands (all districts):

All other raw vegetables (including lettuce) except root vegetables free from foliage, asparagus, aubergines, capsicums, cucumbers, green beans, green peas, marrows, mushrooms, onions, shallots, pimentos, pumpkins, tomatoes and witloof chicory; 1 April – 30 April.

From the Netherlands (Westland district and the Islands of the Province of South Holland only):

Cauliflowers, summer and winter varieties (trimmed); 1 April – 31 May

Consignments of such raw vegetables must be accompanied by an official certificate, indicating that the plant products involved are believed to conform with the current phytosanitary regulations of the importing country. They must also fulfil the following requirements:

(*a*) They must have been examined and been found to be free from Colorado beetle infestation; and
(*b*) they must have been grown in a district where an intensive system of control of Colorado beetle is in operation.

News and Notes

Laos Adheres to the International Plant Protection Convention

The instrument of adherence of the Government of Laos to the International Plant Protection Convention, dated 21 February 1955, was received by the Director General of FAO on 28 February 1955. The number of countries contracting to the Convention, including both signatory and adhering members, is at the time of writing twenty-seven, namely: Argentine, Australia, Austria, Belgium, Cambodia, Canada, Ceylon, Chile, Denmark, Dominican Republic, Egypt, El Salvador, Greece, India, Iraq, Japan, Korea (Republic of), Laos, Luxembourg, Netherlands, New Zealand, Pakistan, Republic of the Philippines, Spain, Sweden, United Kingdom and Yugoslavia.

FAO Plant Protection Meeting for South East Asia and Pacific Region

The Plant Protection Meeting for the South East Asia and Pacific region was held, under the auspices of FAO, in Singapore, 13 to 17 December 1954, for the purpose of formulating a regional agreement to prevent the invasion of dangerous diseases and pests from outside the region. The Meeting was attended by representatives of the Governments of Australia, India, Indonesia, Laos, the Netherlands, Portugal, Thailand, the United Kingdom, the United States and Viet-Nam, and by an observer of the South Pacific Commission.

The need for a regional agreement for the promotion of cooperative action to protect rubber and other important plant resources in South East Asia was previously considered at the Phytosanitary Conference convened by the Commissioner General for the United Kingdom in South East Asia in 1949. The Conference recommended that a regional phytosanitary convention be established and a permanent advisory commission be set up to give effect to the objects of the convention. The proposed convention, however, was never formally negotiated and, at the suggestion of several governments in that region, FAO assumed the responsibility of negotiating such a regional agreement within the framework of the International Plant Protection Convention.

The FAO Meeting, considering that the South East Asia and Pacific region is still free from some serious diseases and pests of economic crops, felt that in the interests of the economic stability and agricultural progress of the region, this position should be maintained as long as possible through united action and co-operation by all governments involved. To this end, the Meeting adopted a draft Plant Protection Agreement for the South East Asia and Pacific Region, as a supplementary agreement to the International Plant Protection Convention. The draft Agreement provides for measures regulating the import of plants from outside the region as well as the movement of plants within the region, and for the establishment of a regional committee as an advisory body to participating governments on matters relevant to the Agreement. Included in the draft are two appendices, one consisting of a list of destructive diseases and pests which are not yet established in the region and against the introduction of which special caution should be exercised, and another providing for specific measures for the exclusion of the South American leaf blight (*Dothidella ulei*) of hevea rubber.

In accordance with the recommendation of the Meeting, this draft Agreement will be submitted to the next session of the FAO Council for approval and, subject to the Council's agreement, will be submitted to all governments responsible for territories in the South East Asia and Pacific region for acceptance.

Roma - Tip. del Senato del dott. Giovanni Bardi